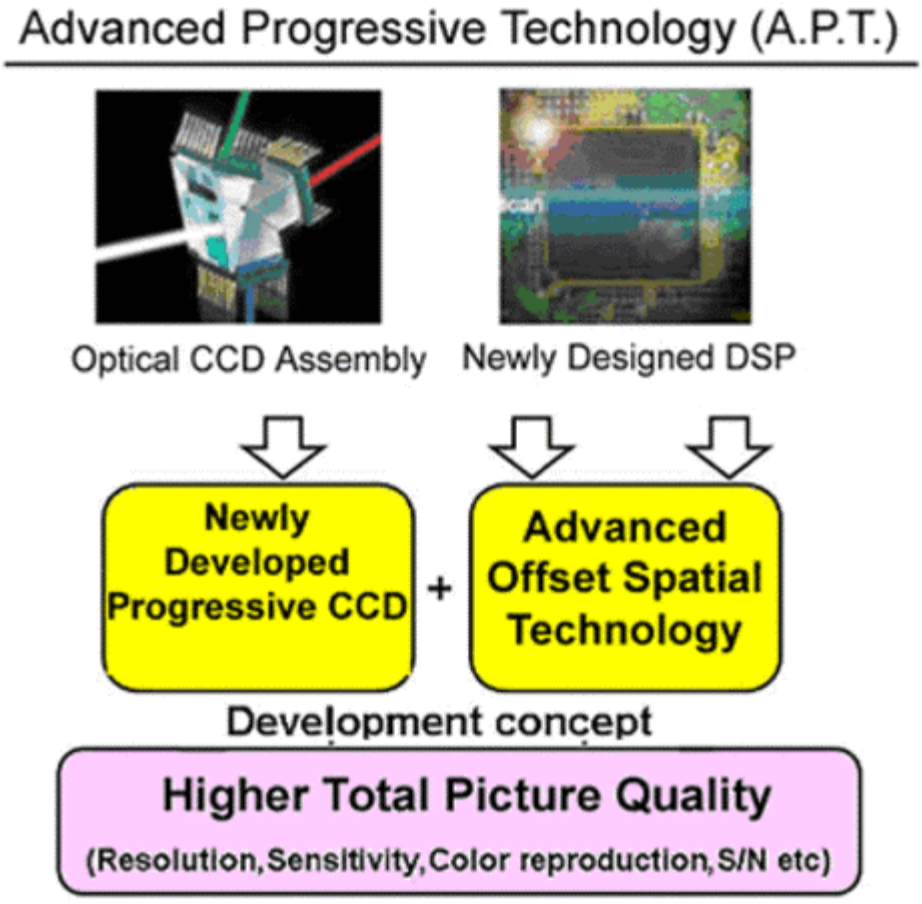
Panasonic's Design and Development of the AG-HVX200 – A History

The AG-HVX200 continues to redefine high quality yet cost effective HD acquisition. From its inception, Panasonic intended to create a camera that could produce compelling content for the Independent Filmmaker and the News Stringer - as well as the wide variety of HD and SD professional applications in-between. While that seems like a tall order, we believed that it was possible because we had created such a camera in Standard Definition with our AG-DVX100 series. By analyzing its success, we worked to match its strengths with similar functionality in the HD Domain for the HVX200.

The Chip Set

All camera design begins with 3 elements: the image capture section, the signal processing section, and the compression storage section, and the most important of these is the Imager set. Knowing that the camera needed to do SD and HD, Panasonic surveyed the technologies and their respective "trade-offs". If we used a 1/3" native resolution 1920 x1080 CCD, it wouldn't have enough sensitivity to be practical in low light because the pixels would be too small to collect sufficient light. Likewise, a 1/3" 1280 x 720 native resolution CCD would require such a radical architectural change to achieve reasonable sensitivity and dynamic range that it would create image artifacts. These artifacts render the CCD questionable for many applications. Interlace image capture provides a gain in initial sensitivity that may permit smaller pixels but then the inherent image quality and flexibility of a true progressive imager is lost. With those options and limitations well defined, it seemed that none of these technologies answered the needs that we heard coming from customers. Customers wanted a camera that would perform in Low Light, have good Dynamic Range and still have the resolution to work in the HD domain.

Clearly the challenge in creating the best image was to find the optimal pixel density and size to balance sensitivity and dynamic range with resolution in a true progressive imager. The result? The HVX200 uses a technology that we have named Advanced Progressive Technology or A.P.T. This solution cleverly employs a spatial offset (a well known resolution enhancing technique) in 2 planes (biaxially) simultaneously to allow the use of larger pixels than one would have thought possible.



Take another look at the three technologies discussed above and contrast them with the Spatial Offset strategy. The chart directly below shows the native resolution of the Panasonic HD chip array along with others currently on the market. One can see only Panasonic utilizes biaxial spatial offset that is both a horizontal and a vertical shift.

	Pixel count	Type	Spatial Offset Methodology
Panasonic	960 x 540	Progressive	Horiz. / Vert.
Company A	960 x1080	Interlace	H only
Company B	1280 x 720	Progressive	None
Company C	1440 x 1080	Interlace	H only

While pixel count is one of the many important factors that determine picture quality, it is not the only one that should be considered. Using a progressive type chip along with a precise implementation of Spatial Offset can optimize the resolution that is possible.

In general, two important concepts need to be considered:

(a) Spatial Offset technology will improve the resolution by a factor of 1.5 provided the gain in resolution is not offset by the quality of the lens.

(b) Interlace CCD resolution is equivalent to 70% of the vertical pixel count of the progressive CCD.

So, if one were to apply the Spatial Offset formula (for each manufacturer that has it) to their chip set and reflect the impact of being interlace (for those that are) the table above would be changed to the following:

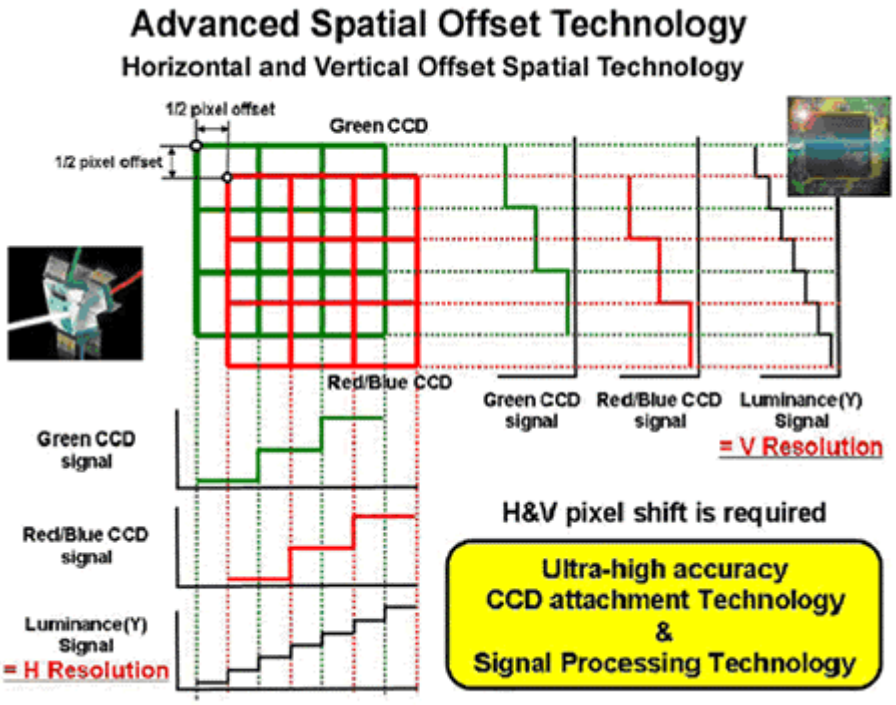
	Pixel count	Type	Pixel shift
Panasonic	1440 x 810	Progressive	Horiz. / Vert.
Company A	1440 x 756	Interlace	H only
Company B	1280 x 720	Progressive	None
Company C	2160 x 756	Interlace	H only

Certainly this is a theoretical “best case scenario” and other factors must be taken into consideration when designing a camera such as the HVX200. For a 1/3” imager, increasing pixel density beyond an optimum level will decrease the Modulation Transfer Function, even though lines of resolution might increase. Modulation Transfer Function (MTF) is a quantitative measure of imager quality to describe the ability of the lens to transfer object contrast. Creating a good-

looking and reasonably sensitive Standard Definition Imager in the 1/3” format is very difficult; creating a 1/3” HD imager with a usable sensitivity is even more difficult. Sensitivity and dynamic range are determined by the capacity of the charge well that defines a pixel, and this is determined by the size of that pixel. The grain structure of film must contend with the same rules. Big pixels or film grains are more sensitive than small ones, and smaller imagers require smaller pixels to achieve a similar resolution. For a camera to work in news applications, or any “run and gun” operation, a minimum sensitivity and dynamic range must be delivered.

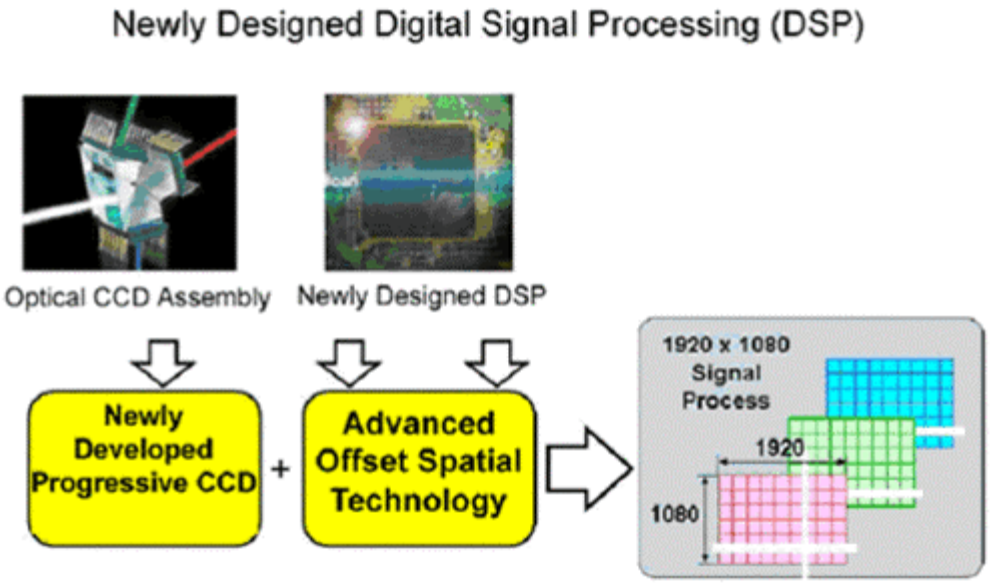
Panasonic moved ahead with the decision to use a 960 X 540 progressive imager in conjunction with the Horizontal and Vertical Spatial Offset strategy. This strategy provides the HVX200 with the low light performance and the dynamic range that we’ve heard from customers was critical in their applications.

The diagram below illustrates how additional resolution can be gained by Pixel Shift or Spatial Offset of the red and blue elements with respect to green.



The optical block for this professional DVCPRO HD camcorder is assembled using highly accurate, patented technology to precisely set the Horizontal and Vertical pixel shift to ½ pixel. This gives the advantage of better dynamic range and sensitivity with minimal compromise in resolution.

Digital Signal Processing



The Optical CCD Assembly output (from the R, B and G image sensors) is then converted into a digital electronic signal. At this point the signal processing circuit becomes the next most important element in determining the camera's performance. For the AG-HVX200, Panasonic designed a new Digital Signal Processing (DSP) chain using 14 Bit A/D conversion with a 19 Bit DSP system. This allows for extreme control over the images. Strategically this DSP is always working in the 1080 progressive mode (at either the 60 or 50 frame rate, depending upon the geographically defined model). This means the optical image is converted to a 1080 progressive picture (1920 x 1080 pixel count) inside of the DSP. From there all image processing will be performed in the 1920 x 1080 domain, and it is only after this stage that format conversion takes place.

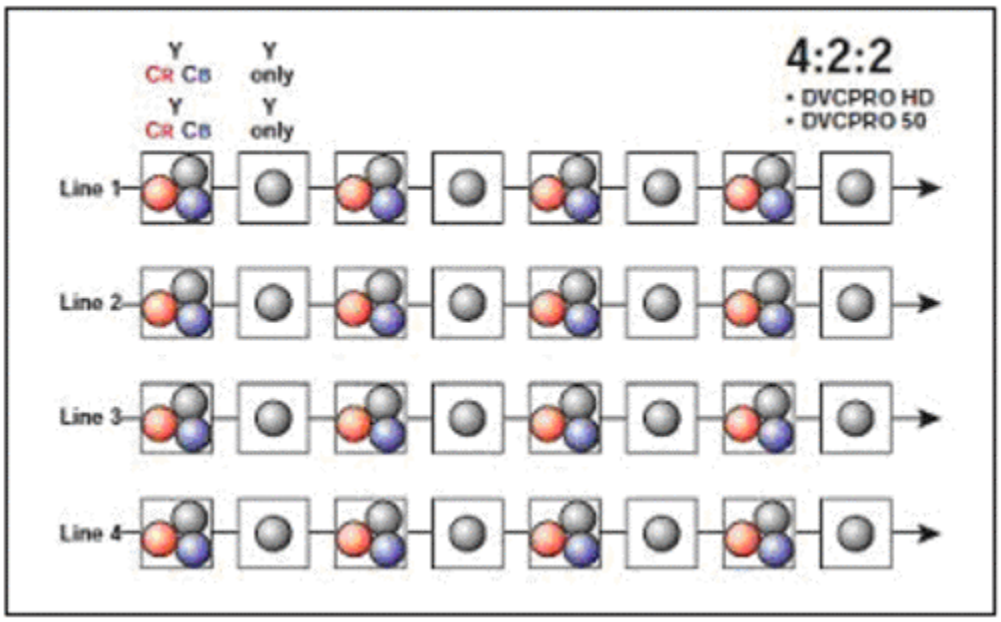
For example, if a 720P/24PN signal is desired, this conversion happens following the DSP image manipulation in order to produce the maximum image quality.

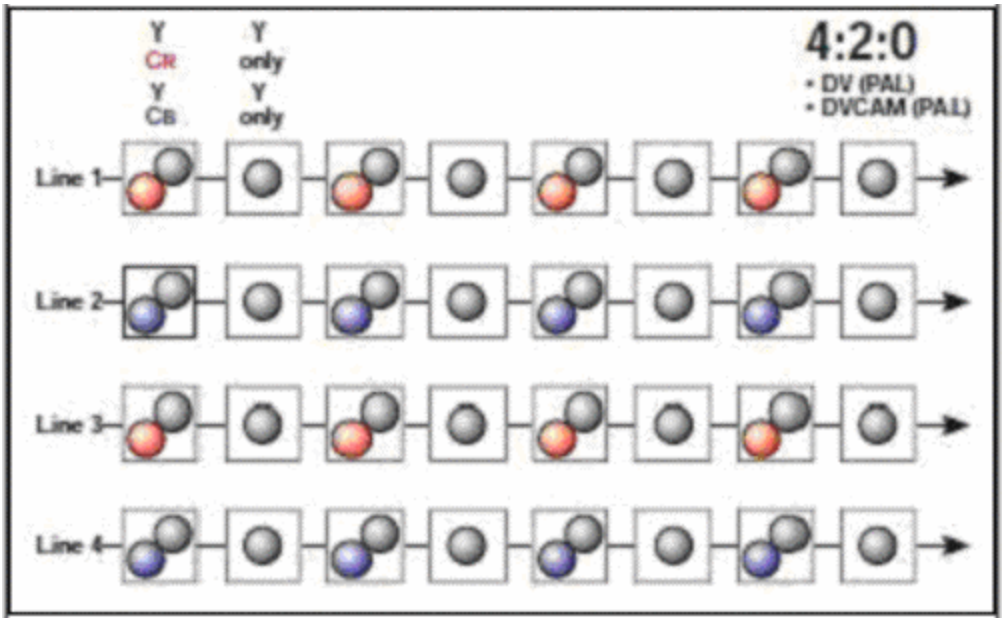
Intra Frame DVCPRO HD Compression

The AG-HVX200 capitalizes on the well-founded and well-accepted extensible DVCPRO algorithm, an intra frame compression scheme that lends itself to post-production manipulation. Each frame stands on its own - data is produced and compressed independently for each frame, even in the case of High Definition. This maintains superior pictures and ultimate flexibility. This is especially true when shooting high speed moving objects, panning the camera, or employing the over-crank and under-crank capabilities of the camera. The beauty of the camera is that it can even act as its own frame rate converter so that special effects can be reviewed immediately.

Although AG-HVX200 is optimized for DVCPRO HD recording in either 1080 or in 720, it also works very well in the DVCPRO50, DVCPRO25 and DV domains. Having this flexibility makes it the GO-ANYWHERE, RECORD-ANYTHING camera.

All but the 25Mb formats sample color at 4:2:2, this means the luminance signal (Y) and the chroma signal (Pb/Pr) have a high quality color ratio. Because 4:2:2 sampling offers higher color resolution, it minimizes “jaggies” at chroma edges - and thus is suitable for image compositing (Top Illustration, below). DVCPRO, DV (NTSC), and DVCAM (NTSC) use a 4:1:1 sampling rate. DVCAM (PAL) and DV (PAL) use a 4:2:0 sampling rate (Second Illustration, below). Although these are formats where the color signal resolution is half of what one gets in 4:2:2 sampling, the degradation of the video quality during post-production is less than that from a structure like that of HDV, which uses a different version of 4:2:0 sampling wherein the luminance line does not correspond to the color difference line.





Ultimately all of the decisions that were made in the design, planning and development stages of the AG-HVX200 camcorder were to allow the capture of great images. If the camera as a tool stands in the way of creativity, Panasonic did not succeed in their objectives. The success or failure of those early decisions can best be judged by the resulting images. So far, the results have been resoundingly positive.